United States General Accounting Office

GAO

Report to the Chairman, Committee on Foreign Relations, U.S. Senate

January 1998

NUCLEAR NONPROLIFERATION AND SAFETY

Uncertainties About the Implementation of U.S.-Russian Plutonium Disposition Efforts

19980123 038

GAO/RCED-98-46

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-278690

January 14, 1998

The Honorable Jesse Helms
Chairman, Committee on Foreign
Relations
United States Senate

Dear Mr. Chairman:

The United States and Russia have accumulated large stockpiles of plutonium—a key ingredient in the production of nuclear weapons. Removing excess plutonium irreversibly from both countries' stockpiles—thereby precluding its reuse in nuclear weapons—is a major policy initiative of the Clinton Administration. The United States is implementing a long-term program to achieve the disposition of about 50 metric tons of excess U.S. plutonium by converting it into forms that would eventually be suitable for permanent disposal.[1] In July 1997, Russia's President established a working group to develop a plan for Russia's plutonium disposition.

As requested, we are providing you with information on (1) the goals of the Department of Energy's (DOE) plutonium disposition program and the impediments facing its implementation, (2) U.S. government officials' views on the importance of a U.S.-Russian agreement on plutonium disposition and the status of efforts to negotiate an agreement, (3) the costs to implement plutonium disposition programs in the United States and Russia, and (4) experts' views about the potential nonproliferation impacts of the U.S. plutonium disposition program. In addition, this report provides information on the U.S. nuclear weapons that are among the sources of plutonium for DOE's disposition plan. (See app. I.)

Results in Brief

DOE's plutonium disposition program seeks to decrease the risk of nuclear proliferation by reducing U.S. plutonium stockpiles by about half to approximately 50 metric tons over the next 25 years and by influencing Russia to take reciprocal actions. Ultimately, U.S. executive branch officials advocate Russia's reducing its stockpiles to levels that are

[1]In accordance with the results of its environmental and nonproliferation impact assessments, the Department of Energy is focusing on two disposition technologies: (1) immobilizing the plutonium by mixing it with glass or ceramics and storing it in large canisters that are filled with high-level radioactive waste and (2) using the plutonium in mixed oxide fuel to be burned in commercial nuclear power reactors which will also generate electricity.

equivalent to those in the United States.[2] Achieving these mutual reductions is a formidable challenge because DOE's immobilization and mixed oxide fuel technologies have not yet been demonstrated on an industrial scale in the United States (although mixed oxide fuel is widely used in Europe), and licensing, regulatory, and environmental issues will need to be addressed for both disposition options. Furthermore, the Russian plutonium stockpile is estimated to be about twice as large as the U.S. stockpile, and Russia may not have the financial resources to implement its program in a time frame that would be comparable to the U.S. disposition schedule. According to some U.S. executive branch officials, the success of the U.S. plutonium disposition program depends on Russia's implementing a similar program because a U.S.-only program could be seen as putting the United States at a strategic disadvantage and would not be supported by the Congress or the international community. Other officials noted that there are risks and costs if the United States does not pursue a plutonium disposition program even if Russia does not implement a similar program.

Executive branch officials told us that a plutonium disposition agreement between the United States and Russia should be negotiated before large-scale expenditures are made for U.S. plutonium disposition facilities. At the time of our review, no formal negotiations had begun to implement such an agreement. Executive branch officials told us that several critical issues will have to be addressed to achieve a binding bilateral agreement, including the quantities of plutonium to be dispositioned, the time frames for completing both countries' programs, the safeguarding of nuclear material prior to disposition, and the funding arrangements.

DOE's preliminary estimates indicate that implementing the U.S. disposition program, which focuses on two technologies to convert plutonium to safer, more proliferant-resistant forms, could cost approximately $2.2 billion over the next 25 years. The cost for a similar program in Russia could range between $1 billion and $2 billion, according to DOE's estimates. U.S. assistance to Russia's program is expected to total between $40 million and $80 million over the next 5 to 7 years and includes plans to construct a pilot-scale plutonium conversion facility. Russia will require significant international assistance beyond what the United States expects to contribute to implement a disposition program. For both commercial and security reasons, several western European countries may be willing to contribute to this effort. However, DOE officials told us that due to

[2]These officials include representatives from the departments of Energy and State, the White House Office of Science and Technology Policy, and the U.S. Arms Control and Disarmament Agency.

funding uncertainties, the U.S. cost to support Russia's program could increase over time if assistance from other countries is not forthcoming and the United States decides to absorb those costs.

Differing views exist among representatives of the U.S. government, private industry, and nongovernmental groups about the potential nuclear nonproliferation impacts of DOE's plutonium disposition program. Some representatives contend that DOE's decision to consider burning plutonium in the form of mixed oxide fuel in commercial nuclear power reactors may pave the way for plutonium recycling in the United States, which would reverse a long-standing policy. Furthermore, there is a concern that western assistance would help create an industry for mixed oxide fuel in Russia that does not now exist and would increase opportunities for the diversion or theft of nuclear materials. DOE officials and representatives from the U.S. nuclear industry told us that the disposition program does not conflict with or reverse established U.S. policy—as some critics contend—because it does not include reprocessing and recycling and is limited to plutonium from the weapons program. Executive branch officials have also stated that the mixed oxide fuel fabrication facility that would be constructed in Russia should be used only for the disposition of weapons plutonium until all declared excess weapons plutonium is processed. They also said that no mixed oxide fuel should be reprocessed, at least until all stockpiles of surplus weapons plutonium in Russia have been eliminated. State Department officials said these conditions will have to be addressed in a future binding agreement with Russia.

Because it is uncertain when such an agreement will be signed, the Congress may wish to link DOE's future requests for program funding to assurances that Russia will take binding reciprocal actions.

Background

From World War II to the end of the Cold War, the United States and the former Soviet Union produced large quantities of plutonium to build nuclear weapons. With the lessening of tensions between the United States and Russia, efforts began to reduce the inventory of both countries' excess plutonium. In early 1994, Presidents Clinton and Yeltsin endorsed the goal of nuclear arms reduction and directed experts to begin studying options for the long-term disposition of plutonium and other nuclear materials.

In 1995, the United States declared that 38.2 metric tons of weapons-grade plutonium was no longer needed for national security and was, therefore,

excess.[3] DOE also designated 14.3 metric tons of non-weapons-grade plutonium as excess. Because a portion of the plutonium declared excess is scrap or residue with low contents of plutonium, it is unsuitable for fabrication into mixed oxide (MOX) fuel and is better suited for immobilization instead. According to DOE, plutonium scheduled for disposition will come primarily from (1) metal that may have been in a retired nuclear weapon,[4] (2) oxides, (3) unirradiated fuel, and (4) irradiated fuel. Securing plutonium derived from these sources will require conversion into forms that meet the "spent fuel standard." This standard, which was introduced by the National Academy of Sciences and endorsed by DOE, requires that plutonium be made roughly as unattractive and difficult to retrieve and use in nuclear weapons as the plutonium that exists in spent fuel from commercial nuclear power reactors. DOE plans to convert about 50 metric tons of excess plutonium into forms suitable for eventual disposal. Of the total, DOE plans to immobilize about 17 tons and could process the remainder as MOX fuel, although a final decision on whether to burn or immobilize this plutonium has not been made.[5]

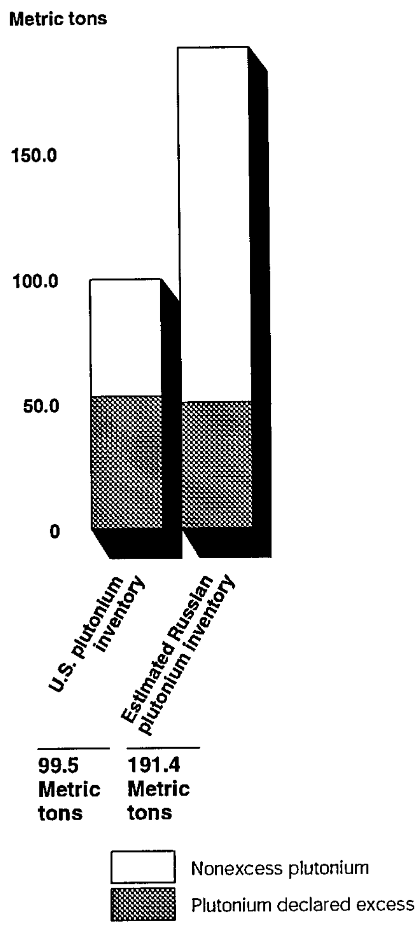
As figure 1 shows, it is estimated that Russia has about twice as much weapons-usable plutonium (consisting of weapons-grade and other grades) as the United States.

[3]Plutonium is primarily a man-made element, produced by irradiating uranium in nuclear reactors. Weapons-grade plutonium is the grade of plutonium preferred by nuclear weapons designers.

[4]Retirement refers to an administrative decision to remove the warheads from the nuclear weapons stockpile and dismantle them.

[5]For more information on U.S. plutonium disposition issues, see Department of Energy: Plutonium Needs, Costs, and Management Programs (GAO/RCED-97-98, Apr. 17, 1997).

Figure 1: Estimates of Total U.S. and Russian Stockpiles of Weapons-Usable Plutonium



Note 1: This inventory does not include plutonium from commercial nuclear power operations.

Note 2: According to the Stockholm International Peace Research Institute, seven other countries may have possessed another 17 to 26 metric tons of plutonium, excluding plutonium from commercial nuclear power operations.

Sources: Oak Ridge National Laboratory and GAO.

At the April 1996 Summit on Nuclear Safety and Security held in Moscow, the leaders of the G-7 countries plus Russia called for further study of ways to manage excess nuclear materials, including plutonium.[6] In October 1996, representatives from many countries, including the United States and Russia—as well as representatives from private industry—met

[6]The G-7 members are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The European Union participates in G-7 discussions and working groups.

in Paris and concluded that (1) the safe and effective management of excess nuclear materials is technically feasible; (2) no solution is rapid, simple, and inexpensive; and (3) two existing technologies—burning the plutonium as a fuel in nuclear reactors and immobilizing the plutonium in glass or ceramics—are viable, complementary disposition options.

An interagency group has been established in the United States under the joint chairmanship of the White House Office of Science and Technology Policy and the National Security Council to oversee plutonium disposition. DOE, as the agency with primary responsibility for managing the disposition of plutonium, established the Office of Fissile Materials Disposition, which is responsible for implementing nuclear materials storage and disposition. This office has the technical lead for disposition-related technological activities with Russia, which are coordinated by the Office of Science and Technology Policy.

DOE Seeks Reductions in Plutonium Stockpiles, but Disposition Program Faces Uncertainties

U.S. executive branch officials told us that the United States and Russia should ultimately reduce their plutonium stockpiles to equivalent levels. However, achieving these reductions is a formidable challenge because DOE's immobilization and MOX technologies have not been demonstrated on an industrial scale in the United States, and licensing, regulatory, environmental, economic, and transparency (assurance that plutonium to be dispositioned comes from weapons) issues need to be addressed for both disposition options. Furthermore, Russia may not have the financial resources to implement its program in a time frame that would be comparable to the U.S. disposition schedule.

In January 1997, DOE formally announced that it would pursue two technologies to convert excess plutonium to safer, more proliferant-resistant forms. For planning and analysis purposes, DOE anticipates converting about 50 metric tons of excess plutonium over the next 25 years. The total U.S. plutonium inventory is approximately 99.5 metric tons. On the basis of preconceptual design data and preliminary plans, DOE estimates that implementing its plutonium disposition program—excluding long-term storage—will cost approximately $2.2 billion. This amount includes DOE's costs to immobilize plutonium as well as to burn MOX fuel. By using a disposition strategy that uses both technologies, DOE hopes to maximize the likelihood of the U.S. program's being successfully completed. DOE also hopes that the U.S. plan for MOX fuel will provide additional encouragement for Russia to undertake a reciprocal disposition program.

According to U.S. government officials, ultimately it is important that both countries agree to reduce their remaining plutonium stockpiles to equivalent levels. The Deputy Minister of Russia's Ministry of Atomic Energy (MINATOM) told us that Russia's only acceptable disposition option for the bulk of its excess plutonium is burning it in nuclear power reactors because Russia considers the plutonium a valuable source of energy. The Deputy Minister also noted that Russia favors burning MOX fuel because this process—unlike immobilization—changes the content of the plutonium, thereby making it difficult to use in a nuclear weapon.[7] However, according to State Department officials, MINATOM's Minister has also stated that immobilization may be acceptable for scrap and low-grade residues.

According to DOE officials, the United States will not fully implement its plutonium disposition program unless Russia implements a comparable plutonium disposition program. DOE's Acting Director of the Office of Fissile Materials Disposition told us that it would be unacceptable for DOE to request full funding to convert approximately 50 metric tons of U.S. plutonium into more proliferant-resistant forms without Russia taking corresponding actions. DOE officials told us that, in their opinion, a U.S.-only plutonium disposition program would not be supported by the Congress because it could put the United States at a strategic disadvantage. Furthermore, by acting unilaterally, the United States would lose leverage in future negotiations with Russia on plutonium disposition. A Department of State official told us that other nations would be concerned that a program involving only the United States would have a marginal impact on reducing the worldwide risks of nuclear proliferation. Officials from the U.S. Arms Control and Disarmament Agency (ACDA) noted that there are risks and costs if the United States does not pursue plutonium disposition even if Russia does not implement a similar program.

Disposition Technologies Have Not Been Demonstrated on a Large Scale in the United States

DOE's plutonium disposition program is expected to be completed in about 25 years but faces technological uncertainties that could increase program costs and time frames because neither disposition technology has been demonstrated on an industrial scale in the United States. Although immobilization has been used for other purposes, it has never been used on a large scale for plutonium disposition. Unresolved questions include

[7]Administration officials noted that while weapons-grade plutonium is preferred for weapons, either the United States or Russia could produce weapons from reactor-grade plutonium having reliable explosive yields, weights, and other characteristics generally comparable to those of weapons-grade plutonium.

how the plutonium will react in the immobilization processing, how stable and durable the immobilized material will be, and how difficult it will be to recover the plutonium from the immobilized forms and use it in nuclear weapons.

MOX fuel derived from reactor-grade plutonium has been used extensively in nuclear power reactors throughout Europe, and the technology is well established. Although the technology is well known, the United States has no nuclear power reactors licensed by the Nuclear Regulatory Commission to burn MOX fuel. Furthermore, MOX fuel derived from weapons-grade plutonium has not been burned in commercial nuclear power reactors except on a test basis in Russia. The United States has no facilities to make MOX fuel and DOE has not determined the number or locations of the commercial nuclear power reactors that will be needed to burn MOX fuel.[8] Resolving these issues will depend not only on the development of the disposition technologies but also on contract negotiations with nuclear reactor owners, licensing requirements, and environmental reviews. However, according to DOE, the overall technical risk of either disposition option is relatively low.

Uncertainties also exist with the underground repository where DOE plans to permanently dispose of excess plutonium. While DOE assumes that a permanent repository at Yucca Mountain, Nevada, will be ready to accept the plutonium in 2010 (12 years later than originally planned), it can not be certain that the repository will open. DOE is currently assessing the Yucca Mountain site to determine its viability.[9]

Uncertainties Facing the Implementation of a Plutonium Disposition Program in Russia

According to U.S. executive branch officials, Russia's plutonium disposition efforts are not as advanced as U.S. activities and face impediments, including Russia's ongoing production of weapons-grade plutonium. Russia produces about 1.5 metric tons of plutonium each year at nuclear reactors at Tomsk and Krasnoyarsk. The plutonium is produced by Russian reactors that also provide heat and electricity to nearby cities. In 1994, Russia agreed to shut down those reactors by 2000. However, in 1997, the United States and Russia signed an agreement to modify the reactors rather than permanently shut them down, as a means of stopping

[8]DOE has initiated efforts for designing, constructing or modifying, licensing, and operating a MOX fuel fabrication facility in the United States. A contractor is expected to be selected by September 1998.

[9]See Nuclear Waste: Impediments to Completing the Yucca Mountain Repository Project (GAO/RCED-97-30, Jan. 17, 1997).

the production of weapons-grade plutonium. The United States has been providing assistance to complete the modifications, although progress in implementing the agreement has been slow.

U.S. officials believe, however, that Russia is making some progress toward establishing a framework for a plutonium disposition program. For example, in July 1997, Russia's President Yeltsin established a committee under his Defense Council to oversee Russia's plutonium disposition, including developing a plan. Furthermore, in September 1997, President Yeltsin declared that Russia would remove up to 50 tons of plutonium from its stockpile over time—roughly the same amount that the United States declared excess. According to DOE, the costs for the disposition of about 50 metric tons of plutonium in Russia could range from $1 billion to $2 billion.

In developing a plutonium disposition program, Russia faces the same technological issues as the United States. Furthermore, Russia's ability to undertake a successful program depends upon international financial assistance. According to the Deputy Minister of MINATOM, the pace of Russia's program will depend on the financial support it receives from the international community, including the United States. France and Germany are considering financing—with some Russian support—a pilot facility in Russia to convert plutonium into MOX fuel. French government officials told us, however, that although the donor governments can be expected to provide some of the financing, most of it will have to come from European investors. They noted that private investment is uncertain because potential investors may not be willing to accept the financial risk without some assurances that the MOX fuel fabrication enterprise in Russia will be commercially viable.

Officials from DOE, the State Department, and the White House Office of Science and Technology Policy, as well as representatives from some nations with a commercial and/or security interest in supporting Russia's disposition efforts (e.g., France, Germany, Canada, and Belgium), told us that insufficient funding is a major obstacle to implementing a disposition program in Russia. As is the case in the United States, major capital expenditures are needed in Russia to build a plutonium conversion plant, construct a MOX fuel fabrication facility, and modify and license nuclear power reactors to burn the MOX fuel.

Russia's limited number of nuclear power reactors that are capable of burning MOX fuel could affect its ability to disposition its excess plutonium

in a time frame comparable to that of the United States. Although Russia has seven operational VVER-1000 pressurized water reactors,[10] which are capable of burning MOX fuel, DOE officials and other experts said that it is possible that Russia could use up to six of these reactors. In addition, another type of reactor, a BN-600 at Beloyarsk, could be used.[11] According to Canadian officials, if Russia's four VVER-1000 reactors and the BN-600 reactor were used to burn the MOX fuel, it would take at least 40 years to burn about 50 metric tons of Russia's plutonium. According to DOE, if Russia also used the two other VVER-1000 reactors, the plutonium could be burned in 28 years.

A 1996 State Department analysis noted that if Russia's VVER-1000 reactors were used, their planned 30-year operating lives would have to be extended. This extended usage could have an impact on the overall cost of the Russian program because modifications to the reactors may be required. Figure 2 shows the location of Russia's VVER-1000 reactors, a BN-600 reactor, and the sites where weapons-grade plutonium has been or continues to be produced.

[10]The VVER-1000 reactors have more safety features than earlier Soviet-designed nuclear power reactors. For example, these reactors have containment structures similar to those in Western nuclear power reactors. According to DOE, Western experts believe that, with some modifications, these reactors could meet internationally acceptable levels of safety.

[11]A BN-600 is a type of reactor designed to use plutonium in MOX fuel.

Figure 2: Location of Russia's VVER-1000 Nuclear Power Reactors, BN-600 Reactor, and Plutonium Production Sites

Note : The numbers within the symbols show the number of reactors at each site.

DOE officials said that 11 additional VVER-1000 reactors operating in Ukraine could be used to burn plutonium, thereby accelerating the rate of disposition. According to DOE, an additional VVER-1000 reactor, if completed, could also be used. Russia's Deputy Minister for Atomic Energy told us that there have been some preliminary discussions with

Ukraine's government officials about using their reactors to burn MOX fuel and that they did not have serious concerns about using their reactors.

Although concerns exist about the number of VVER-1000 reactors that Russia may use to burn MOX fuel, experts believe these reactors can burn the fuel derived from weapons-grade plutonium safely. Officials from DOE, Oak Ridge National Laboratory, and the International Atomic Energy Agency, as well as representatives from France, Belgium, and Germany, told us that it is technically feasible for MOX fuel derived from weapons-grade plutonium to be used in these reactors. While some of these officials recognize that additional testing and analysis is required, they told us that there are no major technical impediments to burning MOX fuel safely.

According to a September 1996 U.S.-Russian plutonium disposition study,[12] preliminary analyses indicate that the VVER-1000s could safely burn MOX fuel, though some modifications to the reactors might be necessary. The study (1) estimated that the cost to modify the seven VVER-1000 reactors totaled $77 million and (2) noted that Russia could complete construction of three partially built VVER-1000 reactors, which could help increase the consumption of MOX fuel. The cost to complete the reactors could range from $500 million to $750 million.

U.S. Officials Recognize a Bilateral Plutonium Disposition Agreement Is Needed

According to officials from DOE, the Department of State, and the White House Office of Science and Technology Policy, an agreement between the United States and Russia on plutonium disposition should be negotiated before large-scale expenditures are made for U.S. disposition facilities. These officials said that a bilateral agreement should address such major issues as the following:

- the quantities of plutonium to be dispositioned by both countries and the amounts of plutonium that will remain in their respective military stockpiles;
- the dates when both sides plan to complete the dispositioning of their excess plutonium;
- the methods to ensure that plutonium and disposition facilities are properly safeguarded to reduce the risks of diversion and/or theft;

[12]The study, which is formally known as the Joint United States/Russian Plutonium Disposition Study, was developed by government officials and scientists representing the United States and Russia. It was transmitted to Presidents Clinton and Yeltsin by the Assistant to the President of the United States for Science and Technology and the Russian Minister of Minatom.

- the assurances that the plutonium to be dispositioned will be subject to verification and inspection measures;
- the assurances that the facilities to fabricate MOX fuel will only be used for plutonium disposition until all declared excess weapons plutonium is processed through them and that spent nuclear fuel will not be reprocessed and recycled for continued use in civilian nuclear power reactors as long as Russia has surplus stocks of weapons plutonium; and
- the funding arrangements.

Obtaining agreement with Russia on the procedures to ensure U.S. access to nuclear materials from dismantled weapons may prove difficult. As we reported in September 1996, the United States and Russia were unable to conclude an agreement specifying exactly how prior Russian assurances of access would be implemented at an interim storage facility at Mayak.[13] This facility, which is partially being constructed with U.S. funds, is expected to store 50,000 containers of material from dismantled nuclear weapons in Russia. The lack of progress in agreeing on inspection rights at Mayak is due largely to a U.S.-Russian impasse on completing a broader agreement on reciprocal access measures.

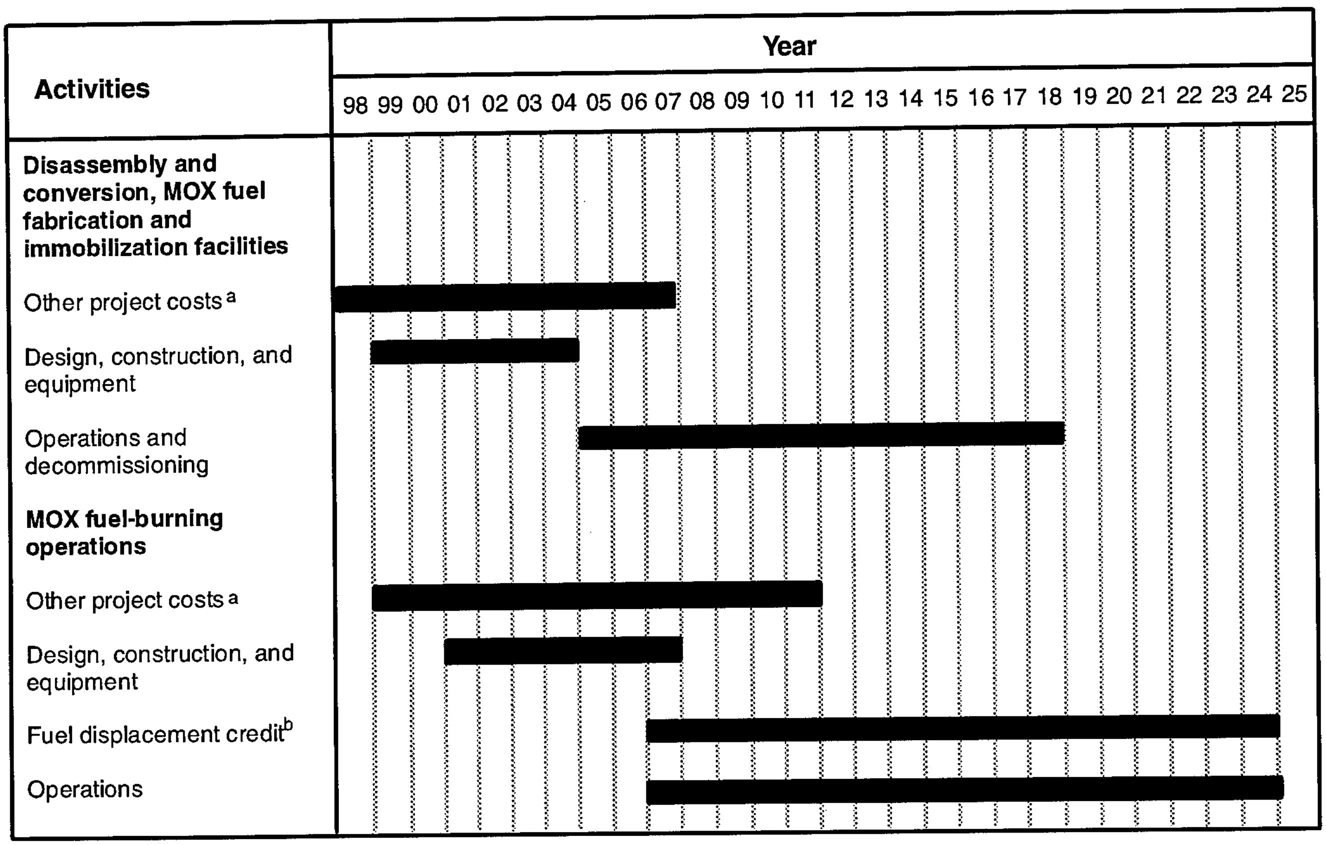
Currently, there are no formal negotiations between the United States and Russia on implementing a plutonium disposition program. U.S. government officials told us, however, that such an agreement should be signed within the next 2 to 3 years or else the future of the U.S. disposition program could be jeopardized. In their view, an agreement should be in place—and Russia needs to begin a parallel program—before the United States begins to spend significant funds to construct U.S. facilities, such as the immobilization facility and associated processing facilities and the MOX fuel fabrication plant. DOE and MINATOM are negotiating a more narrowly focused agreement to address the technical arrangements related to joint testing of disposition technology and pilot-scale demonstrations. However, DOE officials said this agreement does not replace the need for a broader bilateral agreement.

Plutonium Disposition Costs

DOE has not yet made large capital expenditures for its plutonium disposition program. As figure 3 shows, DOE plans to spend about $550 million during fiscal years 1998 through 2007 on design, construction, and equipment projects for disposition-related activities in the United States, including the construction of a facility to fabricate MOX fuel.

[13] Weapons of Mass Destruction: Status of the Cooperative Threat Reduction Program (GAO/NSIAD-96-222, Sept. 27, 1996).

Figure 3: DOE's Estimated Schedule and Costs to Implement the U.S. Plutonium Disposition Program (Dollars in Thousands)



Total = $2,185,285

[a]Includes the costs for research, development and demonstration, conceptual design, licensing permits, some environmental data collection, and facility start-up and training.

[b]Consists of potential cost recoveries from participating utilities' reduction of purchases of conventional uranium fuel.

Source: DOE.

DOE officials estimated that the United States will provide between $40 million and $80 million over the next 5 to 7 years to assist Russia's disposition program. Most of this funding is designated to construct a pilot-scale facility in Russia to convert the plutonium metal removed from nuclear warheads into plutonium oxide, a fine powdery substance of plutonium combined with oxygen. Once in this form, the plutonium would

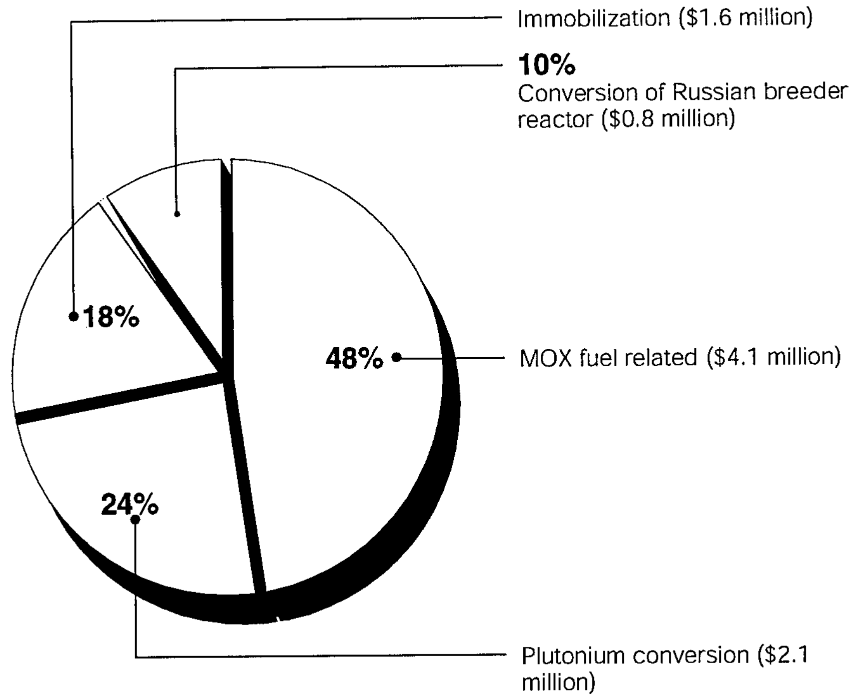
be subject to international inspection and could either be immobilized in glass or ceramics or be used in MOX fuel. According to DOE officials, the pilot facility should begin operations in 2005. They also told us that due to funding uncertainties, the U.S. cost to support Russia's program could increase over time if assistance from other countries is not forthcoming and the United States decides to absorb those costs.

U.S. Cost for Russia's Program

During fiscal years 1995 through 1997, DOE had budgeted \$13.9 million for Russian activities related to plutonium disposition. Of that total, \$8.5 million was budgeted for six joint demonstration technology projects, and \$5.4 million was budgeted for studies, travel, weapons dismantlement, and support provided by DOE's national laboratories and the Amarillo National Resource Center for Plutonium.[14] The demonstration projects include (1) burning a modified type of MOX fuel in a Canadian reactor, (2) fabricating MOX fuel pellets, (3) validating computer codes for analyzing VVER-1000 reactors, (4) studying the feasibility of converting a Russian reactor so it can burn MOX fuel, (5) studying ways to change plutonium from dismantled nuclear warheads into safer forms and store them, and (6) developing immobilization technologies. Appendix II discusses the status of these demonstration projects. Figure 4 shows the distribution of the \$8.5 million for these projects.

[14] In 1994, DOE entered into a 5-year \$51.5 million cooperative agreement with Texas to establish the Amarillo National Resource Center for Plutonium. Approximately \$2 million of the Center's budget has been used to fund Russian activities related to plutonium disposition.

Figure 4: Distribution of $8.5 Million for U.S.-Russian Plutonium Disposition Demonstration Projects Through Fiscal Year 1997



Note 1: DOE reported that about $4 million had been spent on these projects as of July 31, 1997.

Note 2: MOX fuel-related projects include verifying safety data, fabricating MOX pellets, and fabricating VVER-1000 MOX fuel.

Note 3: Total costs does not equal $8.5 million due to rounding.

Source: DOE.

Views on Impact of DOE's Plutonium Disposition Program Differ

Representatives of the U.S. government, private industry, and nongovernmental groups have differing views about the potential effects of DOE's plutonium disposition program on nuclear proliferation. Some representatives contend that DOE's decision to consider burning plutonium in the form of MOX fuel in commercial nuclear power reactors may pave the way for the future use of plutonium in the U.S. nuclear industry through plutonium reprocessing. Furthermore, there is a concern that Western assistance would help create a MOX fuel industry in Russia that does not now exist and would increase the risk of the diversion or the theft of nuclear material.

DOE's decision to burn plutonium in the form of MOX fuel in commercial nuclear reactors has focused attention on plutonium's value as an energy source but also has raised concerns about nuclear proliferation. The United States does not encourage the civilian use of plutonium and does not engage in plutonium reprocessing to generate nuclear power.[15] However, many countries, including France, Belgium, Germany, the United Kingdom, Russia, and Japan, believe that plutonium is a valuable fuel and have programs to reprocess and recycle it.

DOE officials and representatives from the U.S. nuclear industry told us that the disposition program does not conflict with or reverse established U.S. policy—as some critics contend—because it does not include reprocessing and recycling and is limited to plutonium that has been separated from nuclear weapons. They have maintained that by burning MOX fuel without reprocessing, the United States is focusing on ultimately eliminating plutonium, not creating more. According to DOE, controls will be placed on the program for fabricating MOX fuel. For example, the U.S. government would own and control the MOX fuel fabrication facility, which would be located at a DOE site. Furthermore, the facility would only be used for the disposition program, and no spent fuel would be reprocessed or recycled. DOE and White House Office of Science and Technology Policy officials stated that DOE's MOX fuel program will not provide the United States any plutonium reprocessing capability that is not now readily available on the commercial market.

In contrast, other government officials, a member of Congress and representatives from nongovernmental organizations, such as the Institute for Energy and Environmental Research, have indicated that DOE's decision to pursue the MOX fuel option may pave the way for the future civilian use of plutonium in the United States. For example, they believe that the disposition program will provide experience in making and using MOX fuel that the United States does not now have. Others maintain that burning MOX fuel will establish a precedent that would serve to justify the future commercial use of plutonium. They also contend that the activities of the civilian nuclear industry have been kept separate from military activities to reduce the risk of nuclear proliferation and to encourage the rest of the world to maintain a similar standard.

A November 1996 memorandum from the Director of the U.S. Arms Control and Disarmament Agency (ACDA) highlighted many of these

[15]The President's 1993 nonproliferation and export control policy states that "The United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes."

proliferation concerns. According to the Director, (1) using MOX fuel would establish an infrastructure, at least in part, for the domestic civil use of plutonium; (2) employing both disposition technologies would undermine U.S. efforts to discourage the reprocessing of plutonium in other countries, such as South Korea and Russia; and (3) placing the two options on equal footing would be contrary to U.S. nonproliferation policy.

Subsequently, ACDA's Director acknowledged that reserving the right to use both the MOX fuel and immobilization options was consistent with U.S. policy. ACDA officials told us that their agency's concerns had been significantly tempered because DOE's final disposition plan, announced in January 1997, did not favor one disposition strategy over another. The officials noted, however, that ACDA still favored immobilizing the plutonium rather than burning MOX fuel for the United States because they believed it appeared to be less costly, quicker to implement, and left the plutonium as unlikely to be stolen or diverted as the MOX fuel option.

U.S. Seeks to Limit Proliferation Risks in Russia

A 1996 analysis prepared by an official from State Department's Office of Nuclear Energy Affairs concluded that the use of weapons-grade plutonium in Russian nuclear reactors posed certain proliferation risks. The document noted that Western assistance would help create a MOX fuel industry that does not now exist and that Russia might otherwise be unable to build. The use of MOX fuel could provide Russia with the infrastructure to reprocess plutonium for both civilian and military purposes and thereby encourage a plutonium economy. According to DOE officials, however, Russia already has a significant reprocessing capability.

The Administration's position has been that (1) a MOX fuel fabrication facility constructed with international assistance in Russia should be used only for the disposition of weapons plutonium and (2) no spent MOX fuel should be reprocessed and recycled at least until all excess weapons plutonium has been processed. State Department officials said they want to preclude Russia's increasing its stockpiles of plutonium as a by-product of converting military plutonium into more proliferation-resistant forms. They also said that Russia has not yet accepted the provision related to the future use of the MOX fuel facility and the reprocessing of spent nuclear fuel. Representatives from France, Belgium, and Canada told us their governments support the U.S. position.

Conclusions

DOE's plutonium disposition program faces uncertainties related to costs, licensing, regulatory and environmental issues, and the further development of disposition technologies. Furthermore, the U.S. program depends heavily on Russia's adoption of a similar program that also faces many impediments. Given these uncertainties, DOE is pursuing its own plutonium disposition program, on a modest scale at this time, without Russia's commitment to implement a similar program that proceeds along similar time frames. While the United States ultimately wants to reduce both countries' stockpiles of plutonium to equivalent levels, it is unclear if the Russian government endorses this objective. Furthermore, it is uncertain if Russia—and the international community, including the United States—is willing to make the financial commitment to achieve these reductions in Russia over time.

Matters for Congressional Consideration

Because of the uncertainties about Russia's commitment to implement a program similar to the U.S. program, the Congress may wish to consider linking DOE's future funding requests for large-scale projects to design and construct plutonium disposition facilities in the United States and Russia to the progress being made in negotiating and signing a bilateral agreement. Furthermore, the Congress may wish to consider requesting that the Department of State, and other appropriate agencies, report periodically on efforts to conclude a plutonium disposition agreement between the United States and Russia.

Agency Comments

We provided copies of a draft of this report to the White House Office of Science and Technology Policy, the departments of Energy and State, and ACDA for review and comment. The Office of Science and Technology Policy provided its own comments and also obtained and consolidated comments from the other agencies. On December 17, 1997, we met with the office's Assistant Director for National Security and DOE's Assistant to the Director for International Programs, Office of Fissile Materials Disposition, to discuss their comments. In general, the agencies agreed with the facts and analysis presented and noted that our report correctly observed that there are uncertainties associated with both the U.S. and Russian plutonium disposition programs. The agencies also noted that MOX fuel technology is well established in Europe. We have expanded our discussion on MOX fuel technology to make it clear that while the technology is widely used in Europe it still has not yet been demonstrated on an industrial scale in the United States. The agencies reiterated that the U.S. government will not begin to commit large amounts of funds to either

the U.S. or Russian plutonium disposition programs until Russia commits to a comparable program. Furthermore, they emphasized that both programs should be implemented in roughly parallel time frames. The agencies also provided us with additional clarifying information that we incorporated as appropriate.

Scope and Methodology

To address our objectives, we interviewed officials and obtained documents from the departments of State and Energy (and several national laboratories), ACDA, and the White House Office of Science and Technology Policy. We also obtained information from various foreign governments, commercial institutions, and international organizations, including the International Atomic Energy Agency and Russia's Ministry of Atomic Energy. Our scope and methodology are discussed in detail in appendix III.

We performed our review from February 1997 through December 1997 in accordance with generally accepted government auditing standards.

Unless you publicly announce its content earlier, we plan no further distribution of this report until 5 days from the date of this letter. At that time, we will send copies of this report to other interested congressional committees, the Secretaries of State and Energy, the Assistant to the President for Science and Technology Policy (Office of Science and Technology Policy), the Director of ACDA, the Director of the Office of Management and Budget, and other interested parties. We will also make copies available to others upon request.

Please contact me at (202)512-8021 if you have any questions. Major contributors to this report are listed in appendix IV.

Sincerely yours,

Gary L. Jones

Gary L. Jones
Associate Director, Energy, Resources,
and Science Issues

Contents

Abbreviations

ACDA	U.S. Arms Control and Disarmament Agency
CANDU	Canadian Deuterium Uranium Reactor
DOE	Department of Energy
GAO	General Accounting Office
ICBM	Intercontinental Ballistic Missile
INF	Intermediate-Range Nuclear Forces Treaty
MINATOM	Russian Ministry of Atomic Energy
MOX	mixed oxide fuel
OSTP	White House Office of Science and Technology Policy
START	Strategic Arms Reduction Treaty

U.S. Nuclear Weapons That Are Sources of Plutonium for DOE's Disposition Plan

DOE's programmatic environmental impact statement for plutonium disposition analyzes the disposition of about 50 metric tons of excess weapons-usable plutonium over the next 25 years. Included in that amount is 21.3 metric tons that can be traced to nuclear warheads that have been retired. Retirement refers to an administrative decision to remove the warheads from the nuclear weapons stockpile and to dismantle them. DOE and the Department of Defense conducted a joint review and determined that 21.3 metric tons of plutonium, most of which came from classes of warheads fully retired between 1970 and 1993, was excess to national needs. The other 28.7 metric tons in DOE's analysis came from such other plutonium-bearing sources as components, metals, and oxides that were by-products from the production of nuclear weapons.

Retirements of warheads have occurred for several reasons including treaties and weapons modernization efforts that supplant the need for some older or less reliable warheads[1]. For example, a 1991 report of the Committee on Armed Services, U.S. House of Representatives, identified concerns about the W69, a warhead for air-launched missiles on bomber aircraft. The warhead did not have such modern design features as fire-resistant plutonium. The concern was that an accident involving the warhead could scatter plutonium over a wide area or, in the very worst and far less likely case, result in a nuclear explosion.

Table 1.1 lists the fully retired classes of warheads that are sources of plutonium scheduled for disposition.

Table 1.1: Fully Retired Classes of Nuclear Warheads That Contain Plutonium Scheduled for Disposition

Warhead[a]	Type of weapon	Year weapons entered stockpile	Year all weapons were retired
B28	Thermonuclear bomb carried by strategic and short-range aircraft[b]	1959	1991
B43	Bomb carried by strategic and short-range aircraft	1961	1991
B54	Special atomic demolition munition capable of being placed by a two-person team	1964	1989

(continued)

[1]The Intermediate-Range Nuclear Forces (INF) Treaty ratified by the United States and the former Soviet Union on June 1, 1988, called for the elimination of missiles with a range of 300 to 3,400 miles, such as the U.S. Pershing II missiles and Soviet SS-20 missiles. The Strategic Arms Reduction Treaty (START-I), signed July 31, 1991, mandates substantial reductions over 7 years in the number of strategic ballistic missiles and heavy bombers and their associated nuclear warheads. For example, each country must reduce its stockpile of warheads on its missiles and bombers to 6,000. No existing arms control agreement requires that nuclear weapons be dismantled or their plutonium be accounted for. The United States and Russia are unilaterally dismantling warheads.

Warhead[a]	Type of weapon	Year weapons entered stockpile	Year all weapons were retired
B57	Multipurpose nuclear depth charge and nuclear bomb for antisubmarine warfare and land warfare	1967	1993
W44	Warhead for an antisubmarine rocket aboard surface ships	1961	1989
W45	Warhead in missiles and medium atomic demolition munition placed by a team	1962	1988
W48	Atomic projectile fired from a howitzer	1964	1992
W50	Warhead for the short-range Pershing ballistic missile	1963	1991
W55	Warhead in a rocket launched from a submarine to destroy an enemy's submerged submarine	1964	1990
W56	Thermonuclear warhead in the Minuteman II Intercontinental Ballistic Missile (ICBM)	1963	1993
W59	Minuteman ICBM warhead	1962	1970
W66	Anti-ICBM warhead	1974	1986
W68	Warhead on a Poseidon submarine-launched ballistic missile	1975	1993
W69	Short range air-to-surface missile warhead carried aboard strategic bombers	1972	1993
W70	Warhead in a mobile-guided surface-to-surface short-range ballistic missile	1974	1992
W71	Thermonuclear warhead for an anti-ICBM	1975	1993
W79	Atomic projectile fired from a howitzer	1986	1992

[a]These designations refer to specific types of nuclear warheads that were mass-produced nuclear devices capable of being carried by missiles, aircraft, or other means.

[b]A thermonuclear weapon, also referred to as a hydrogen weapon, derives its energy largely from fusion. Existing treaties refer to intercontinental ballistic missiles (ICBM) and other weapons that have a maximum range exceeding 5,500 kilometers as strategic. Intermediate weapons have ranges between 1,000 and 5,500 kilometers, and short-range weapons have a range of less than 1,000 kilometers.

Source: Sandia National Laboratories is the source for the approximate dates. The type of weapon is based on U.S. Nuclear Weapons: The Secret History by Chuck Hansen (1988, Orion Books) and the Natural Resources Defense Council's U.S. Nuclear Forces and Capabilities by Thomas B. Cochran, William M. Arkin, and Milton M. Hoening (1984, Ballinger Publishing Company).

In addition, a small portion of the 21.3 metric tons of excess plutonium comes from individual retired warheads among the current classes of warheads. Current warhead classes are listed in table 1.2.

Table 1.2: Current Warheads in the Active U.S. Stockpile

Warhead	Type of weapon	Year entered stockpile
B61	Multipurpose thermonuclear bomb	1966
B83	Strategic thermonuclear bomb	1983
W62	Warhead on Minuteman III ICBM	1970
W76	Warhead for the submarine-launched Trident ballistic missile	1978
W78	Warhead on Minuteman III ICBM	1976
W80	Warhead on cruise missile	1983
W84	Warhead for ground-launched cruise missile	1983
W87	Warhead for the MX/Peacekeeper ICBM	1986
W88	Warhead for submarine-launched Trident II ballistic missile	1990

Sources: Sandia National Laboratories is the source for the approximate dates. The type of weapon is based on U.S. Nuclear Weapons: The Secret History by Chuck Hansen (1988, Orion Books) and the Natural Resources Defense Council's U.S. Nuclear Forces and Capabilities by Thomas B. Cochran, William M. Arkin, and Milton M. Hoening (1984, Ballinger Publishing Company).

Department of Energy-Russian Demonstration Projects for Plutonium Disposition Technology

This appendix discusses six U.S-Russian plutonium disposition demonstration projects. These projects include burning MOX fuel in a Canadian reactor, fabricating MOX fuel pellets, validating computer codes for analyzing VVER-1000 reactors, studying the feasibility of converting a Russian reactor so that it can burn MOX fuel, studying ways to change plutonium from dismantled nuclear warheads into safer forms and to store it, and developing immobilization technologies.

U.S.-Russian-Canadian Project to Burn MOX Fuel in a Canadian Nuclear Reactor

The purpose of this demonstration project is to examine the technical feasibility of burning weapons-grade plutonium in existing Canadian Deuterium Uranium (CANDU) reactors. The United States and Russia are studying the possibility of using these reactors for this purpose, but a substantial amount of analysis is required. These reactors, which use uranium fuel, may provide a technically attractive option because their design allows them to handle MOX fuel with fewer changes than would be expected with light water reactors. Studies have indicated that CANDU reactors could burn MOX fuel at a greater rate than U.S. reactors. Oak Ridge National Laboratory is coordinating the effort to test MOX fuel from the United States and Russia in a Canadian test reactor—the National Research Universal Reactor.

The scope of the project involves fabrication, irradiation, and post-irradiation examination of a small number of MOX fuel rods over 18 months. Fuel rods are hollow metal tubes that contain fuel pellets. Los Alamos National Laboratory has fabricated seven fuel rods for use in the demonstration. Russia's A. A. Bochvar All-Russia Scientific Research Institute is expected to fabricate another 8 to 10 fuel rods to combine with the U.S. fuel rods. As originally conceived in 1995, a total of 92 fuel rods—46 manufactured in the United States by Los Alamos National Laboratory and 46 fabricated in Russia—would be made for assembly in four fuel bundles. The test irradiations and post-irradiation examinations will be conducted at the Chalk River Laboratory in Canada.[1] This trilateral effort will permit evaluation of such technical issues as possible differences between U.S. and Russian MOX fuel performance.

DOE had planned to facilitate the signing of a contract between Atomic Energy of Canada Limited, the designer of the CANDU reactor, and the Bochvar Institute in July 1996. As part of that effort, DOE would pay for manufacturing the Russian fuel, transporting it to a Russian port, and for

[1]More than 350 MOX fuel elements, using reactor-grade plutonium, have been irradiated at experimental reactors at this facility, including a prototype CANDU reactor.

licensing oversight in Russia. The contract, however, was not signed then because of disagreements about the amount of money that would be provided to the Bochvar Institute to fabricate the MOX fuel, the intellectual ownership of the fabrication rights, the legal implications of transporting plutonium outside of Russia, and the possible imposition of Russian taxes on U.S.-funded assistance.

The U.S. fuel has not been delivered to Canada because the United States was awaiting resolution of the disagreements concerning the Russian contract. In July 1997, Bochvar Institute officials indicated their agreement to the proposed contract. The signing occurred in September 1997, and the shipment is expected to be made sometime in calendar year 1998. DOE reported expenditures totaling $402,000 for this project as of July 31, 1997, and has planned $455,000 for continued work in fiscal year 1998.

Fabrication of VVER-1000 MOX Fuel

The purpose of this demonstration project is to assist and encourage Russia to (1) develop a MOX fuel fabrication process that is compatible with surplus weapons-grade plutonium, (2) test the resulting fuel, and (3) qualify it for use in a VVER-1000 reactor. The data and information collected in this task will be provided to Gosatomnadzor, Russia's nuclear regulatory authority, and Rosenergoatom, the Russian utility that operates the nuclear power reactors, to facilitate the eventual licensing of MOX fuel in Russia.

Oak Ridge National Laboratory is responsible for performing the work on behalf of DOE. In January 1997, a contract was signed by the University of Texas at Austin and the A.A. Bochvar All-Russia Research Institute,[2] which established the statement of work, budget, schedule, and list of deliverables for the initial phase of work. Under the terms of this contract, the Bochvar Institute will receive $210,000 for various technical reports and for manufacturing a limited amount of test fuel related to the use of MOX fuel in VVER-1000 reactors. According to laboratory officials, the program to develop and test MOX fuel will be continued under separate contracts that will be signed with the appropriate Russian organizations.

According to the Oak Ridge project manager, the project has made little progress because the Bochvar Institute has not prepared an acceptable plan to test the MOX fuel, has not provided a MOX fuel specification, and has

[2]The University of Texas at Austin signed contracts on behalf of the Amarillo National Resource Center for Plutonium, a consortium of the Texas A & M University System, Texas Tech University, and the University of Texas System. Through a cooperative agreement with Texas, DOE provided about $2 million to the Center for Russian-related plutonium disposition activities.

limited ability to handle plutonium on site. The project manager said that the original Russian test plan did not contain the level of detail required to plan and execute the MOX fuel development program. The test plan is critical to the project because it outlines the goals, the time frames, and the estimated costs for manufacturing and testing MOX fuel in Russia.

Laboratory officials noted that a contract has been placed with another Russian institute, the Research Institute of Atomic Reactors, to complement the current work and to perform the follow-on work that will require larger plutonium inventories. According to DOE, this institute should be capable of performing the required manufacturing work with limited equipment modifications and upgrades. Because the Bochvar Institute has been designated as the lead technical institute in Russia for all reactor fuel development, it will remain involved with the development program. The delay in the program and the reasons for it have been raised to higher levels within MINATOM without resolution. According to DOE, $443,000 had been spent on this project as of July 31, 1997, and DOE has planned $600,000 for continued work in fiscal year 1998.

Validating the Performance of MOX-Fueled Nuclear Reactors

Having available verified and validated computer codes that have been used to predict the behavior of MOX fuel derived from weapons-grade plutonium is essential for nuclear regulatory organizations to complete their evaluations.[3] This joint U.S.-Russian project is designed to begin the process of verifying and updating these computer codes that both U.S. and Russian regulators will need to license reactors to use MOX fuel. The verification process uses safety data that has been compiled by various international organizations and commercial organizations. Using the results of these verifications in Russia must have the concurrence of the original designer of the VVER-1000 reactor and the Russian institute responsible for the initial calculations of the reactor core's physics. The United States will take similar verification actions once the type of U.S. reactor has been selected.

In 1996, the University of Texas at Austin and the Russian Institute of Physics and Power Engineering entered into a $205,000 contract for which

[3]Regulatory authorities in the United States as well as in the Russian Federation depend on analysis using computerized models of power- reactor physics and thermal hydraulics to gain confidence that the reactor can operate without endangering its operators and the public. Simulating reactor operations through computerized models is much faster and far less expensive than conducting reactor experiments for all possible operating and accident conditions. However, when a model is used, the user must have confidence that the simulation is acceptably accurate. To check the model's accuracy, its results are compared to results that have already been obtained experimentally from tests conducted in reactors.

Russian authorities were required to provide various deliverables, including verification and validation studies in a form suitable for presentation to the Russian nuclear regulatory agency for licensing approval. Oak Ridge National Laboratory is responsible for coordinating this Russian work on behalf of DOE.

Oak Ridge is also working with Russia's Kurchatov Institute, Russia's leading research and development institution in the field of nuclear energy, and the Institute of Physics and Power Engineering. This work is designed to assess the ability of Russian and U.S. computer codes to produce calculations on reactor physics that are consistent with experimental data and with the results produced by computer codes that are available in the international nuclear community. The results of the U.S. and Russian calculations will be evaluated with respect to how well the experimental results were predicted and the U.S. and Russian results will be compared. This process will provide an independent and parallel validation of the Russian models that may be acceptable to Russia's nuclear regulatory authority.

The initial phase of the work has been completed, and Oak Ridge officials indicated that they were pleased with the results. Follow-on work will be started in fiscal year 1998 and will be expanded to validate codes for rapidly changing and accident conditions. DOE reported expenditures totaling $912,000 for this project as of July 31, 1997, and has planned $700,000 for continued work in fiscal year 1998.

Converting a Russian Breeder Reactor to a Plutonium Burner

DOE has agreed to help Russia assess the feasibility of converting Russia's BN-600 reactor, a fast-neutron reactor, into a reactor suitable for burning weapons-grade plutonium. The BN-600 is a demonstration fast breeder reactor (one that produces more plutonium than it consumes) but operates on a fuel cycle that consumes uranium. When converted, the reactor may be used as a net consumer of weapons-grade plutonium. Studies indicated that the reactor would be capable, with modifications to the reactor core, of burning 100 percent MOX fuel. The BN-600 currently uses uranium oxide fuel. To proceed with the conversion plan, significant safety analyses is required.

Oak Ridge National Laboratory is responsible for managing the project for DOE and providing technical support. Oak Ridge has enlisted the support of the Argonne National Laboratory and the Hanford Site to provide training and computer codes to selected Russian organizations, including the

Institute of Physics and Power Engineering. Under the terms of a $100,000 contract between the University of Texas at Austin and the Institute, Russia is responsible for providing several deliverables, including design studies, safety analyses, and an economic analysis. According to DOE, $527,000 had been spent on the project as of July 31, 1997, and DOE has planned $800,000 for this project in fiscal year 1998.

Plutonium Conversion Technology

One of the critical objectives of the DOE-funded test and demonstration projects is selecting a technology to convert the plutonium weapons components from dismantled nuclear warheads into an oxide form that is suitable for temporary storage, international inspection, and disposition. Once this “front-end” process has been completed, the material can be used in MOX fuel and burned in a nuclear reactor to generate electricity. DOE, working with Los Alamos National Laboratory, is studying plutonium conversion technology as part of its own disposition plan. Los Alamos has also been tasked by DOE to lead a concurrent effort with Russia on plutonium conversion. Neither the United States nor Russia has selected the final conversion process.

The goal of the project is to find areas where the United States and Russia can cooperate. In fiscal year 1997, Los Alamos received $2 million to begin a cooperative effort with Russia. DOE is placing significant resources in this program and plans to contribute $40 million to $80 million over the next 5 to 7 years for research and development and for the design and the construction of a pilot-scale plutonium conversion facility in Russia.

According to DOE and Los Alamos officials, the project with Russia has been delayed. The Bochvar Institute, which will be leading and coordinating research on the project, would not sign any contracts for several months until an agreement between DOE and MINATOM was signed. One of the Los Alamos officials told us that the Institute wanted to have the internal political protection of this agreement before starting any work. In July 1997, however, the Deputy Minister of MINATOM instructed the Institute to proceed without the agreement in place.

According to the Los Alamos official, another difficulty has been that the Bochvar Institute has requested extremely high labor rates, which have been unacceptable to DOE and have also delayed progress. The official, who described these matters as “growing pains” that are to be expected with such a program, believed that the pace of the project was beginning

to accelerate as all of the different Russian organizations gained a better understanding of their roles and responsibilities.

As of late August 1997, Los Alamos National Laboratory had signed two task orders with the Bochvar Institute totaling $200,000. The first task order, for $78,000, is to develop a master plan for the joint plutonium conversion and disposition project. The plan is expected to outline the steps for determining the optimum conversion process for plutonium metal into an oxide. In July 1997, the Institute submitted the draft plan for review and it is being revised; it is expected to be finalized in March 1998. As of August 1997, the first deliverable of the task order has been completed and payments totaling $23,200 had been made to the Institute.

In late July 1997, the second task order, for $122,000, was signed to initiate tests and analyses that will lead to the design and development of a nondestructive system to disassemble Russia's nuclear weapons. Under this task, Russia is responsible for preparing a design report and a technical demonstration report. According to a Los Alamos official, several additional task orders are being negotiated with the Bochvar Institute to initiate research on various conversion technologies. In addition, a broad feasibility study and design for the pilot demonstration conversion plant is also being developed as a near-term effort.

According to DOE, $874,000 had been spent on the project as of July 31, 1997. DOE planned an additional $3,000,000 for this project in fiscal year 1998.

Developing Immobilization Technologies

DOE, working primarily through Lawrence Livermore National Laboratory—with support from the Savannah River Site and other laboratories—is engaged in projects with Russia to explore various immobilization technologies. As part of its dual-track approach to plutonium disposition, DOE is studying several options, including immobilization in glass or ceramics. DOE is funding small-scale demonstration projects to encourage Russia to consider the technical merits of immobilization as a disposition option and to gain insight into Russia's immobilization technology.[4]

[4]Immobilization in glass involves dissolving or mixing the plutonium (plutonium dioxide) in glass and pouring the molten glass compound into cans where it cools and hardens. The cans are sealed and mounted in a large canister that is filled with molten glass containing highly radioactive waste. Alternatively, the plutonium may be mixed with a titanium based ceramic material and compressed and processed into very dense pellets. The pellets are put into cans, which are then sealed and put into large canisters. The canisters are filled with molten glass that contains highly radioactive waste.

The Lawrence Livermore project manager told us that Russian views toward immobilization have generally not been very positive because they view plutonium as a valuable energy source. As a result, it has been difficult to obtain concurrence on some project's goals and requirements. He noted, however, that attitudes appear to be changing somewhat in the past several months as dialogues between U.S.and Russian scientists have increased. For example, the July 1997 meeting of the U.S.-Russian Steering Committee in Moscow resulted in a protocol agreement to increase the dialogue by holding a focused U.S.-Russian experts workshop on plutonium stabilization and immobilization.

The University of Texas at Austin is funding projects valued at $360,000 with two Russian institutes to perform immobilization tasks related to (1) establishing the migration of plutonium in hard rock formations in order to prepare for eventual siting, designing, and licensing of a geological repository and (2) providing tests and demonstrations to incorporate plutonium in glass using Russian technologies.

One task, valued at $100,000, includes a technical exchange meeting at Lawrence Livermore National Laboratory, the purchase of equipment used to obtain samples of rock cores from a site in the Krasnoyarsk region of Siberia, and elevated pressure and temperature tests with plutonium in Russia.

The second task, valued at $260,000, which began in January 1997, has been delayed. Under the terms of its contract, the United States is obligated to provide sample glass-fused material to the Bochvar Institute for testing. However, the release of the material was significantly delayed due to export control requirements. In the interim, U.S. requirements for the information changed and the information pertaining to unique Russian melter technology and for the Russian data on U.S. glass compositions will not be needed. Lawrence Livermore is currently working with the University of Texas to modify the contract for no extra cost and to extend the time frames. The proposed modification would be for studying Russian-selected glass compositions capable of containing high concentrations of plutonium using Russian technology.

According to DOE, $863,000 had been spent on this project as of July 31, 1997. DOE has budgeted $1.1 million for continued work on this project in fiscal year 1998.

Scope and Methodology

To obtain information about plutonium disposition issues, we interviewed and obtained pertinent documents from officials at the Department of State, the U.S. Arms Control and Disarmament Agency, DOE, and the White House Office of Science and Technology Policy. We also met with the Deputy Minister of Russia's Ministry of Atomic Energy (MINATOM), who is responsible for matters relating to plutonium disposition. In the course of our review, we also attended several forums that focused on plutonium disposition issues. We attended the Fourth International Policy Forum on the Management and Disposition of Nuclear Weapons Material (Lansdowne, Virginia) and two sessions sponsored by the Nuclear Energy Institute and the Nuclear Regulatory Commission on licensing issues related to the fabrication of MOX fuel. We also met with the chairman of the U.S. delegation to the U.S.-Russia Independent Scientific Commission on the Disposition of Excess Weapons Plutonium.

Cost information was obtained primarily from DOE's Office of Fissile Materials Disposition. We did not independently verify the accuracy of the cost data they provided. We obtained information on the status of various joint demonstration projects from DOE, Lawrence Livermore National Laboratory, Berkeley, California; Oak Ridge National Laboratory, Oak Ridge, Tennessee; Los Alamos National Laboratory, Los Alamos, New Mexico; and the Amarillo National Resource Center for Plutonium. We also met with representatives from Sandia National Laboratories (Rosslyn, Virginia office).

To obtain information about the nonproliferation implications of DOE's plutonium disposition program, we obtained the views of numerous governmental and nongovernmental organizations. Representatives from nongovernmental organizations included the Nuclear Energy Institute, the Natural Resources Defense Council, the Nuclear Control Institute, the Institute for Energy and Environmental Research, the Union of Concerned Scientists, Greenpeace, and the Nuclear Information Resource Service. We also obtained information from the International Atomic Energy Agency (Vienna, Austria), BNFL Inc., and COGEMA, Inc.

We obtained the views of foreign governments on matters pertaining to plutonium disposition. We met with officials from the government of France, including the Ministry of Foreign Affairs and Atomic Energy Commission. We also obtained information from the governments of Belgium, Canada, and Germany. We attempted to obtain information from the governments of the United Kingdom and Ukraine via inquiries made

through their embassies in Washington, D.C. Neither the United Kingdom nor Ukraine responded to our inquiries.

To obtain information on U.S. nuclear weapons that are sources of plutonium for DOE's disposition plan, we interviewed DOE officials who provided documents and discussed the types of plutonium for disposition and the amounts that would come from retired nuclear weapons. We also obtained additional information about particular types of weapons from two documents: Nuclear Weapons Databook: U.S. Nuclear Forces and Capabilities and U.S. Nuclear Weapons: The Secret History. These documents are considered to be authoritative, publicly available sources on the topic.

The National Security Council declined to meet with us and stated that it did not possess any information that could not be obtained from other U.S. government agencies.

Major Contributors to This Report

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